A RECONNOISSANCE IN SANPETE, CACHE, AND UTAH COUNTIES, UTAH.

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GEOGRAPHY AND TOPOGRAPHY.

A portion of July, 1899, was spent in a rapid survey of the alkali soils of Utah, Sanpete, and Cache counties in Utah, with the following results, briefly given. The conditions in these three districts are in general very similar, yet each district differs from the others in certain respects.

Utah County lies directly around the fresh-water lake that bears the same name, and all of its irrigated land is on what was, at a previous epoch, the bed of Lake Bonneville. The soils are the sediments of this ancient lake, more recently modified by the inflowing streams and by weathering.

The irrigation water supply is obtained from the mountain streams, the principal ones being American Fork, Provo River, and Spanish Fork. The source of the water supply for these streams, during the irrigation season, is chiefly the melting snow on the high mountains of the Wasatch Range, and the water is therefore of excellent quality. It contains about 15 parts of soluble matter per 100,000.

The irrigation systems consist of a series of canals and ditches owned and operated by the farmers. Parts of the valley have been under cultivation for about forty years. When the valley was first settled the strip of land immediately around Utah Lake was wet and swampy. By irrigating the upland the wet land has greatly increased in area, this increased wet area becoming less valuable, although still furnishing desirable grazing. The principal damage is from seepage waters, but where the soil is heavy, salts have accumulated at the surface in sufficient quantities to seriously damage the meadows.

Moderate amounts of salts are everywhere present in the soil and through the agency of irrigation and seepage waters they are concentrated within small areas. An examination of the seepage waters from the benches showed comparatively small amounts of salts present, but these mildly charged solutions are often much concentrated by evaporation and give rise to large accumulations of salts in the soil.

Sanpete County is located in the central part of Utah and its farming lands lie in the valleys of the San Pitch and Sevier Rivers. The land lies at a greater altitude than the ancient Lake Bonneville, and the soil formation is therefore somewhat different from that of the preceding county. The valleys are more level and slope more gradually to the mountains than in the lake basin proper.

The irrigation water supply is derived from several sources. Around and above Manti the water is taken directly from the mountain canyons and is good. Ten miles above Gunnison the San Pitch is dammed, thus forming a storage reservoir which supplies water farther down the valley, around the junction of the San Pitch and the Sevier.

The water of this reservoir, at the time it was examined, carried between 50 and 100 parts of soluble matter per 100,000. The lands to the south of Gunnison receive their water supply from the Sevier River, as do also the lands around Richfield. The water of the Sevier River during a part of the year is diverted at a point above Gunnison. Gradually a portion of it returns to the river as seepage and at Fayette it is again all taken out for irrigation. Still farther down, at Deseret, the stream is drained for the third time.

The water as first taken from the river is good; but the second time it is contaminated by the seepage from the Gunnison district. The water in the Fayette Canal contained, in July, 1894, 250 parts of soluble matter per 100,000; while in the Sevier River, just below Fayette, it contained over 300 parts. At Deseret it was probably still worse. The application of water containing more than 300 parts of soluble matter per 100,000 is attended with great risk unless precautions are taken to prevent concentration within the soil.

Cache County lies in the north-central part of Utah, the farming lands receiving water directly from the tributaries of the Bear River. The irrigation water supply is taken from the mountain streams and is of excellent quality.

SOILS.

The soils of the three districts mentioned above are so similar that they may be conveniently discussed under one head. The farming lands of both Cache and Utah counties are all in the Bonneville beds, and the soils were formed from sediments deposited from the ancient lake, and have, since its subsidence, been considerably modified by inflowing streams and by weathering. The soils of Sanpete County lie above the level of the ancient lake and were formed by material brought down from the adjacent mountains. They are very similar, however, to those of the two preceding counties.

In each of the districts the soils in several parts vary from light sand and small gravel, through all grades, to the heaviest and most tenacious clays. The upper benches of the deltas around the mouths of the canyons, and also the shore benches of Lake Bonneville, are covered with gravelly soils, grading down into coarse gravel. These soils are

well underdrained and therefore free from salts, but owing to the thinness of the soil proper, and to the difficulty of applying water and cultivating the soil, they are but little farmed. The soils of the lower benches contain less gravel, but are sandy and of light texture.

Upon the lower and more level parts of these valleys there are great variations in the soils. In those parts farthest from the inflowing streams, where the water movement is slow, the soils are heavy and often contain as high as 50 per cent of clay. As we approach the entrance of streams, where the water movement becomes more and more rapid, the soils are noticeably lighter, grading through loam, sandy loam, and at the mouths of streams becoming sandy or gravelly. Irrigation on the loose soils results in the transportation of considerable salt to the lower and heavier soils, where it is most difficult to get rid of. Around Utah Lake there is considerable of this heavy land that has been more or less damaged by seepage and alkali from the lands above, and in Cache Valley there is a large area of wet clay land which is used for meadow and grazing. Though of considerable value in this way, the value could be much enhanced by drainage and cultivation.

ALKALI IN SOILS.

In Utah and Cache counties both the black and white forms of alkali are present. Originally moderate amounts of alkali were probably everywhere present in the soil, and through the agency of irrigation and seepage waters a part of these salts has been transported and concentrated in local spots.

The three following analyses, by Dr. Cameron, show the approximate composition of alkali from Utah County:

	4160. Crust from shore of Utah Lake.	4161. Black crust, 2 miles N.W. of Provo.	4162. White crust, 3 miles N.W. of Provo.
$CaSO_4$	3.96		
$MgSO_4$	33.68		6.32
Na_2SO_4	10.02		65.73
$NaCl$	52.34	79.09	26.69
Na_2CO_3	0.00	20.91	1.26

The crust, No. 4160, was collected from near the shore of Utah Lake upon a bar surrounded by swamps. The water of the lake contains gypsum in solution. Gypsum acts as a chemical correction for the black alkali, changing it over into sodium sulphate. Here the process has been complete; all of the sodium carbonate has disappeared.

In sample No. 4162 the per cent of sodium carbonate is so small as not to show black in the crust as collected.

The black alkali, where present, is in spots and small areas and its reclamation with gypsum will prove an easy matter.

In Cache County the black alkali is limited to spots and tracts in the west-central part of the valley and is always associated with the white alkali. Gypsum is found in some of the heavier soils and serves a valuable office in ameliorating the severity of the black alkali.

The following analyses, by Dr. Cameron, show the composition of the salts under the two typical conditions:

	4172. Tule swamp crust, 5 miles SW. of Logan.	4174. Black crust, 3 miles SW. of Logan.
$CaSO_4$	2.07	....
$MgSO_4$	39.11	....
Na_2SO_4	36.38	46.38
$NaCl$	22.44	41.06
Na_2CO_3	....	12.56

In Sanpete County the alkali, so far as examined, was all white. The presence of gypsum in nearly all of the soils and in the irrigation waters would lead one to expect this.

The following analyses, by Dr. Cameron, illustrate the variation in the composition of the salts:

	4165. Red crust, 5 miles S. of Gunnison.	4166. White crust, 5 miles S. of Gunnison.	4170. Yellow crust from kaolin mine, 2 miles SE. of Gunnison.	4171. White crust under loose soil from hillside, 3 miles SE. of Gunnison.
$CaSO_4$	1.27	3.14	3	3.51
$NaSO_4$	73.40	89.03	....	95.60
$MgSO_4$	....	....	7.18	....
$MgCl_2$	....	....	4.47	....
$NaCl$	25.33	7.83	85.33	0.89

Samples 4165 and 4166 represent the alkali as found in the soil, while 4170 and 4171 were collected to represent some of the possible sources of the salts. In each of these samples gypsum is present in sufficient quantity to prevent the formation of black alkali in a well-aerated soil. In the foothills south of Gunnison rock salt is mined; the streams cutting through these hills are likely to become contaminated with this salt and carry it to the irrigated lands below, much to their detriment. No actual exposure of the salt is at present visible along the stream beds, but the underground flows and heavy floods, no doubt, carry much of this salt valleyward.

One of the highland canals, running along the base of these hills, leaked in a gravelly place and the resulting seepage at the foot of the hill was heavily charged with salt and formed a heavy crust over the surface of the ground. There is much apprehension that this upland canal, through its seepage, will wash alkali down to the lower, heavier lands and damage them. In order to prevent this the canal should be protected from leakage and great care exercised in the use of water on.

the light soils of the upper slopes. Wherever the level of standing water begins to rise and threatens to come near the surface the land should be underdrained. Protection from seepage is sometimes afforded by a seepage ditch, providing the ditch is dug along an impervious layer which naturally rises, and therefore raises the seepage waters. If no such layer is present a seepage ditch would afford little protection.

Where irrigation waters carry a high percentage of salts, or where the soil is naturally salty, surface flooding is thought to be better than furrow irrigation. By furrow irrigation a crust of salt accumulates along the tops of the furrows to such an extent that in time it may prevent the growth of plants, except in the bottom of the furrows where the water washes down the accumulation of salt from the previous irrigation. By flooding, the salts over the entire surface are washed down and, if drainage be good, they will pass off through the underground drainage, but if the drainage be poor they will return to the surface. To prevent as far as possible the return of salts to the surface, the growth of shading crops or thorough surface cultivation should be resorted to.

There are some plants more resistant to alkali than others, and by the cultivation of these, alkali lands may be at times utilized. Such plants as the Australian saltbush, sugar beets, sorghum, and sweet clover are worthy of trial.

It is found that sweet clover will grow successfully with as much as 1 per cent of salt in the soil. It is a biennial, and therefore easily removed from the land. It is a deep-rooted legume, and consequently loosens the soil and supplies nitrogen. Its blossoms furnish excellent bee food and the leaves and stems are eaten by cattle to some extent. It serves the twofold purpose of improving the land and furnishing forage.

SUMMARY.

The discussion of the conditions in the three counties included in the reconnoissance shows, in all the cases cited, that the presence of alkali salts within the soils is due to defective natural drainage. The obvious remedy is artificial drainage. Where farming is as intensive as it is in some parts of Utah the first step in the natural reclamation of the land, after application of water, should be drainage. This feature of the irrigation question has been neglected and the result has been the damaging of valuable land. The method which should now be adopted for the reclamation of the lands abandoned on account of seepage waters and alkali is the same method which, if originally applied, would have insured against such damage—that is, underdrainage. Tile drains offer the most effective and, in the end, the cheapest method of draining the soil.

The application of gypsum or land plaster can be recommended for the black alkali soils. The effect of the gypsum on such soils is twofold: First, the gypsum improves the physical condition of these heavy lands, that is to say, it renders the soil more loamy in character and

easier to cultivate and drain; and, second, it neutralizes the black alkali, turning it into the white salt. Gypsum is not a chemical antidote for the white alkali, and its application to white alkali lands can be of little value, except in so far as the gypsum improves the physical properties of the soil.

The growth of deep-rooted crops tends to loosen the soil and to permit the free downward movement of the water. This effect, together with the shading of the ground in order to prevent evaporation and the consequent formation of alkali, is well illustrated in the growth of alfalfa.

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